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Permit Writers Guidance Manual for the Location of Hazardous Waste Land Treatment, Storage and Disposal Facilities Phase 2

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The Science Advisory Board (SAB) was requested by the Office of Solid Waste (OSW) to review the draft document listed above. This guidance was prepared by OSW in response to a requirement in Section 3004(o)(7) of RCRA, which requires the Agency to publish "guidance criteria" for identifying areas of vulnerable hydrogeology and to promulgate regulations specifying criteria for the acceptable location of new and existing RCRA facilities. SAB's Environmental Engineering Committee (EEC) conducted this review.

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June 24, 1986

OFFICE OF
THE ADMINISTRATOR

Honorable Lee M. Thomas
Administrator
U. S. Environmental Protection Agency
401 M Street, S. W.
Washington, D. C. 20460

Dear Mr. Thomas:

The Environmental Engineering Committee of the Science Advisory Board has recently completed their review of a draft Agency document entitled "Permit Writers' Guidance Manual for the Location of Hazardous Waste Land Treatment, Storage and Disposal (TSD) Facilities (Phase II)." We are pleased to forward their report for your review. In view of the extremely short deadlines requested for this review, we have already provided informal comments to the staff in the Office of Solid Waste.

The draft Guidance, prepared by the OSW, provides criteria for identifying areas of vulnerable hydrogeology in the location of new and existing RCRA facilities. The Committee believes that the methodology described is adequate for "triggering" a more detailed analysis, but is not comprehensive enough for complete site-specific evaluations. The time-of-travel concept, while simplistic, is technically sound, and integrates various hydrogeological factors into a single measure for evaluating the potential for pollutant migration and exposure.

If you have any questions, or should you wish any further action on our part, please do not hesitate to call on us. We would appreciate a formal response to the conclusions and recommendations presented in this report.

Sincerely,

Raymond C. Loehr

Raymond C. Loehr, Chairman
Environmental Engineering Committee

Norton Nelson

Norton Nelson, Chairman
Science Advisory Board

cc: T. Yosie
M. Williams
A. Day
G. Galen

SAB-EEC-86-016

Report

on the review of the

"PERMIT WRITERS' GUIDANCE MANUAL

FOR THE LOCATION OF

HAZARDOUS WASTE LAND TREATMENT, STORAGE AND DISPOSAL FACILITIES

PHASE II"

by the

Environmental Engineering Committee
Science Advisory Board
U. S. Environmental Protection Agency

June 1986

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SECTION I

PRINCIPAL FINDINGS AND RECOMMENDATIONS

On December 6, 1985, Marcia E. Williams, Director, Office of Solid Waste, (OSW) requested that the Science Advisory Board initiate a review of a draft document entitled "Permit Writers' Guidance Manual for the Location of Hazardous Waste Land Treatment, Storage and Disposal (TSD) Facilities (Phase II)." This guidance was prepared by OSW in response to a requirement in Section 3004(o)(7) of RCRA, which requires the Agency to publish "guidance criteria" for identifying areas of vulnerable hydrogeology and to promulgate regulations specifying criteria for the acceptable location of new and existing RCRA facilities.

The Environmental Engineering Committee was assigned the review, which has now been completed. The Committee concentrated on four technical issues raised by OSW in their request for SAB assistance (see Appendix B), but also commented on other issues they felt were important. A summary of the Committee's principal findings and recommendations follows. More detailed comments will be found in Section III.

General

A. The Phase II Location Guidance is a clear and logical presentation of criteria to be used in evaluating "vulnerable" hydrogeology.

B. The methodology described in the Guidance is suitable for use with well-prepared existing permit application data (though the Committee notes that only a small fraction of the Part B's actually have enough information for making time-of-travel calculations).

C. The methodology is not detailed enough to make a complete site-specific determination, but is an appropriate method for "triggering" a more detailed analysis.

Time-of-Travel Concept

D. Although simplistic, the time-of-travel (TOT) concept is technically sound, and integrates various aspects of hydrogeology into a single measure reflecting the potential for pollutant migration and exposure.

E. The TOT concept depends heavily on the determination of effective porosity, hydraulic gradient and hydraulic conductivity, and the guidance should be more explicit in how data should be collected and used to make these determinations.

The permit applications (Part B) frequently do not have enough information for making these determinations (one study in which an SAB consultant was involved found that only about one application in ten had sufficient data), and specific guidance on what is needed and how it is to be collected must be provided.

10/100 Year Time Frames

F. The technical analyses in Appendix D and the Case Studies do not adequately support the time frames specified in the proposed criteria (10 years for treatment and storage facilities, 100 years for disposal facilities). Other studies should be conducted.

While the case studies are useful, they may provide a false sense of "proof" of adequate protection when site data indicates that the TOT criterion has been met. It would be preferable to determine a TOT that would have been estimated had hazardous chemicals not been disposed of at the site, since this would provide a fairer evaluation of "false-positive" and "false-negative" rates for applications of the criteria (a more extensive discussion of this point will be found in Section III).

Adequacy of the 100-foot Flow Line Distance

G. The selection of a 100-foot flow line distance is adequate for the purposes of the guidance, which should be to trigger further analysis, but will not accurately define hydrogeologic conditions at a specific site.

The 100-foot flow line is a conservative, practical engineering criterion, and as such is adequate for the purposes of the guidance, but it cannot be justified on the basis of hydrogeologic homogeneity or flow pattern predictability.

Additional Factors to be Considered

H. The guidance should include some means of evaluating the effects of seasonal variation on hydraulic gradient, as well as the effects on TOT calculations of the physical and kinetic characteristics of the toxic substances (such as partitioning or decay).

While the Guidance offers logical arguments for not including chemical factors in the TOT calculation, the Committee feels that the Guidance could be strengthened by a discussion of how the TOT would be affected if pollutant transport and transformation were included in the analysis.

SECTION II

INTRODUCTION

Background

In a December 6, 1985 memorandum (see Appendix B), Marcia E. Williams, Director, Office of Solid Waste, requested that the Science Advisory Board review a draft of guidance prepared by OSW on the definition of ground water vulnerability for RCRA facilities, a central facet of the OSW RCRA ground water policy (and very much related to other RCRA provisions, including alternate concentration limits, double-liner variances and waste-ban petitions). In the December 6 memorandum, Ms. Williams asked that the SAB focus its review on the following issues:

A. Whether the time-of-travel (TOT) concept is technically adequate within the context of its use with existing permit application data.

B. Whether the technical analyses of risk associated with the case studies and theoretical modeling presented in Appendix D (of the Guidance) adequately support the specified time frames.

C. Whether the 100-foot flow line distance accurately samples local hydrogeologic conditions (does it identify important influences on flow patterns such as fractures and stratigraphic variations).

D. Whether EPA should consider additional factors to enhance the accuracy of the TOT tests, and if so, how the additional factors should be incorporated into the calculation.

The Phase II Location Guidance has two purposes. It proposes the "guidance criteria" for identifying vulnerable hydrogeology required in Section 3004(o)(7) of RCRA, and sets forth the basis for one of the "criteria for the acceptable location" of hazardous waste land treatment, storage and disposal facilities (Phase I of the Guidance dealt with the other four criteria). Appendices to the Guidance also provide more detailed technical explanations of such things as flow net/flow line determinations, TOT calculation in the unsaturated zone, and risk-based justification of the TOT criteria.

Committee Review Procedures

A Subcommittee of the Environmental Engineering Committee was formed to conduct the review (see roster, Appendix A). Several consultants were added to assist with the review. Because of the extremely tight deadlines imposed by OSW, the decision was made to send copies of the draft guidance to the Subcommittee members well in advance of a meeting. This was done, and on February 12, 1986, an open public meeting was held in Washington, D.C. to receive a briefing on the draft Guidance, and to complete the reveiw. At the conclusion of the meeting, Subcommittee members agreed to prepare individual comments on

the draft. These were then forwarded to Mr. Torno, Executive Secretary of the Environmental Engineering Committee, who assembled all of the comments into a coherent report. This report was then circulated by mail, and Mr. Torno received further comments which were incorporated into this final version for submission to the Agency. While it was not possible to prepare a completed written report for the Agency by the end of February as requested, the Committee was able, at its February 12 meeting, to convey the essence of its review to Agency staff.

SECTION III

DETAILED REVIEW COMMENTS

General

The Permit Writers' Guidance Manual - Phase II is a clear and logical presentation of the criteria to be used in evaluating "vulnerable" hydrogeology. The manual reflects the background and experience of the EPA and the consultants, who played significant roles in its preparation - e.g. the firm of Geraghty and Miller. The classification of ground waters into 3 types is a sound basis for evaluation, comparable to previously established classifications of surface waters. This manual is directed to Class II ground waters, which are defined as current or potential sources of drinking water or other beneficial uses, as contrasted to the special value of Class I and limited use of Class III.

The TOT_{100} concept provides a good basis for integrating various aspects of hydrogeology into a single informative measure. It reflects the potential for pollutant migration and eventual exposure, and seems to be consistent with generally held views of aquifer vulnerability. The guidance for computing the TOT_{100} appears appropriate. In particular, Appendix B on flow net construction is well written and informative.

There is a need, however, for clarification of the intended use of the TOT_{100} criteria. The proper use of the information in this guidance document is to: (a) identify hydrogeology that may cause ground water to be vulnerable to contamination when the site is used for a hazardous waste TSD facility and (b) serve as a trigger or "red flag" when a particular site may be identified as having possibly vulnerable hydrogeology. The Committee recommends that a succinct, explicit statement about the intended use of the document and guidance be included in the Executive Summary and the Introduction to the manual. That statement should indicate that the document is for guidance and the approach is intended to trigger the subsequent careful review of the site and the evaluation of mitigation techniques to assure that groundwater contamination does not occur.

The document indicates (page ES-4), that the purpose of the guidance manual is to define "conditions of vulnerability that would make the site unacceptable for the siting of a hazardous waste facility in the absence of special controls." This definition seems to infer that if a site "fails" the vulnerability test, special controls will be necessary. The Committee does not believe that the approach will indicate that special controls are necessary. As indicated above, the approach is better used to trigger the need for more detailed evaluations. Only after these detailed evaluations will the need for special controls become clear.

The stated belief (page ES-4) also appears inconsistent with the statement on page ES-8 that EPA "recognizes that the vulnerable hydrogeology criteria cannot be the sole determining factor in making decisions on banning certain locations for the purpose of facility siting or in denying permits to existing facilities." An evaluation of this possible inconsistency and clarification (if needed) is suggested.

The statement that: (a) this document is not intended to apply to land treatment units (page ES-9) and (b) the criteria are not intended to be the sole determining factor in making banning decisions or denying permits should be included in the first paragraph of the Introduction (page 1-1) so as to make these important caveats obvious to the reader.

Case studies can be very helpful in any Guidance document to more clearly identify how an indicated approach is to be applied. For each case study, there should be a clear opening statement that identifies what the reader should learn from the case study and how the information in each case study may be used in other situations. It also is recommended that an overall summary of all the case studies be included in the manual. The overall summary should indicate why the particular case studies are included and what the reader is expected to learn from the studies. It is important that any case studies add light and clarity to guidance in addition to bulk.

Time-of-Travel (TOT) Concept

The TOT concept is technically adequate within the context of its use with respect to the ground water hydrology and aquifer characteristics, and provides a good basis for integrating various aspects of hydrogeology into a single informative measure. The concept lends itself to a more consistent, quantitative means of evaluating the vulnerability of ground water at a site than does the use of traditional risk analyses, i.e. determine exposure and compare with effects. It takes into account the significant features of the aquifer and the pertinent parameters to define the flow velocity, reflects the potential for pollutant migration and eventual exposure, and seems to be consistent with generally held views of aquifer vulnerability. The guidance for computing the TOT_{100} appears appropriate. In particular, Appendix B on flow net construction is well written and informative.

In the TOT concept the determination of hydraulic conductivity (K), gradient, and effective porosity are of utmost importance. Consequently, the methods employed to identify these parameters will be under close scrutiny. This document could provide a more clear direction for field investigation programs and laboratory testing. For example, laboratory tests for hydraulic conductivity could be eliminated and more emphasis could be placed on in-situ tests which are more reliable.

The TOT calculation should be based on more than a single set of hydrogeologic conditions. The effects of seasonal fluctuations on water levels, gradients and transient flow conditions should be considered.

A thorough analysis of the sensitivity of the TOT calculation to uncertainties associated with the input parameters should be provided in the guidance manual. The permit applicant should also provide a similar analysis in his/her application so that the confidence associated with the actual result can be estimated by the permit writer.

To provide a basis for the sensitivity analysis, a method (clearly specifying test conditions, tracer, column specifications, hydraulic gradient and flow rate) for the "measurement" of effective porosity should be provided. At least the range of median grain size and total porosities, where the gravity drainable porosity can be substituted for effective porosity, should be provided (similar considerations apply to measurements of hydraulic conductivity).

Quality assurance and quality control criteria should be stipulated, including minimum number and type of core samples for effective porosities or slug tests for K at each point, acceptable replicates and averaging procedures, and minimum sample coverage per stratigraphic unit or unit length of flow path.

Acceptable units for K (i.e. cm/sec or gal/day/ft^2) and I (i.e. cm/m or ft/ft) should be limited and clearly stated. Extrapolations from regional transmissivities or odd units should be discouraged in the interest of data conformity, error minimization and building up a "feel" for the data with the permit writers.

All data transformations, default decisions or inferred porosities from soil types should be well documented.

Technical Validity of Selected Time Frames (10/100 years)

The draft Guidance examines how the criterion for vulnerability corresponds to actual facility performance in a wide variety of hydrogeologic settings using case studies and theoretical modeling. The cases presented where the TOT_{100} was long indicate that no contamination is evident. However, this does not constitute proof that an a-priori determination of a long TOT_{100} (i.e., prior to waste disposal, based on hydrogeological characterization) ensures protection against contamination. For example, it appears that Example 3.7.4 (presumably Love Canal) may have a-priori passed the TOT_{100} test. Yet severe environmental problems ensued, due to the "bathtub" effect, where contaminants entering an aquitard backed up into surface structures. Is this effect rare or common? OSW should determine whether there are other cases that illustrate contamination in spite of site conditions that are conducive to a long TOT. This will give a perspective on whether the vulnerability test should consider additional hydrogeologic conditions beyond flow field considerations.

Appendix D should contain an explicit caveat that emphasizes the utility of the TOT_{100} test as a factor or "trigger" for further hydrogeologic investigations on a case-by-case basis, and not as a fool-proof test for classifying a "safe" site. Anything short of an extensive hydrogeologic investigation cannot serve as a definitive means of proving that a site will be guaranteed as safe.

Although the TOT_{100} test encourages siting in aquitards rather than aquifers, permit writers should be more clearly cautioned about the possibility of channeling ground water through fissures and cracks that can occur in any

subsurface strata. These features should be stressed as necessary for consideration when evaluating a site using the TOT test. It would be helpful to include a number of case studies that illustrate what the permit writer should look for to understand how the TOT_{100} test could be misused to misrepresent a vulnerable location by avoiding to acknowledge the presence of such features.

It would be useful to summarize all the case studies presented in both Appendix D and the Technical Resource Document (TRD) for evaluating facility location. A single table indicating aquifer type, computed TOT_{100}, and the degree of contamination found at each site would be informative if included in Appendix D. A separate brief summary of each case study evaluated in the separate TRD, citing the information above, would make the case studies more useful and more easily distinguishable to the permit writer.

Adequacy of the 100-Foot Flow Line

The use of the 100-foot flow line distance as a measure of vulnerable hydrogeology is adequate for the purposes of the Guidance, but cannot adequately characterize local hydrogeologic conditions.

The range of hydrogeologic conditions in near-surface aquifers is quite wide and diverse. Given the fact that the land has (or will have) been disturbed in the vicinity of these sites, the 100 foot distance probably "samples" the conditions which may have resulted from the facility. It is questionable that the 100 foot flow path can provide a representative sample of large-scale (i.e. local to regional areas) stratigraphy, fractures or flow patterns. Some level of effort should be documented in the permit application to interpret the relative importance of scale-dependent features on the TOT_{100} calculation.

Additional Factors to be Considered

As the locations meeting the TOT_{100} criteria are likely to be aquitards with high ground water tables, it would be useful to include an analysis of how these soil and moisture conditions are likely to influence the likelihood of developing a leak in the first place. That is, once a leak develops, these sites may be preferred, but if the soil conditions substantially increase the likelihood of a leak, some of the advantages may be lost.

The discussion on use of engineered barriers (page 2-15) appears inconsistent with other Office of Solid Waste (OSW) emphases. The assumption on page 2-15 is one of total failure of any liner and leachate collection system and the ineffectiveness of any caps. In the development of other OSW guidance and regulations, considerable emphasis is given to the design and use of proper liners, leachate collection systems and caps. This assumption of total failure and ineffectiveness is not justified by information included in the draft Guidance, and appears to represent an overly conservative worst case situation. If liners and caps are designed using the best OSW guidance, it is not likely that there will be massive failures. It is possible that there may be some leaks over time but not total failure. Unless the document intends to infer that liners and caps prepared using other OSW guidance will fail, it is recommended that the use of engineering barriers (liners, caps, leachate collection systems and related protection approaches) be re-evaluated. This re-evaluation should consider how the time of travel considerations can be modified to include

something less than massive failure and ineffectiveness.

Specific Page-by-Page Comments

In addition to the more general comments offered above, a number of details on specific pages of the draft Guidance need to be changed. These include:

Guidance Manual

Page 2-10: The common use of the term attenuation is very loose. It would be better if retardation processes or mechanisms were discussed relative to the transport mechanisms (i.e. advection and dispersion) and the use of the term attenuation discontinued (see also pages 3-3 and 3-13).

Page 3-2: The "measurement" of effective porosity must be clearly described.

Pages 3-5 to 3-8: It would be useful to encourage the development of a water level history for each site which could be analyzed for flow gradient changes over time.

Page 3-13: Mechanical dispersion is identified as an attenuation mechanism. While it is true that dispersion reduces both steady-state and peak concentrations, it also hastens the arrival of the leading edge of the plume. This reduction in travel time for the plume front may be the most important impact of dispersion and related phenomena (e.g. macropore channeling). Note that TOT's calculated are for the center of mass of a contaminant pulse, and the contaminant front will generally arrive much sooner.

Page 3-13: Sorption should be substituted for absorption, since the former is a more general term. Mechanical dispersion is a transport mechanism, and has nothing to do with retardation.

Page 3-15 (Table 3.3-1): The uncertainty associated with the inputs to the TOT equation and the result should be clearly detailed for the permit writer if it is to be applied properly.

Page 4-4: The discussion of passive measures to slow waste migration should be reworded to minimize ground-water flow, since predicting contaminant transport is not the aim of the TOT concept.

Page 6-2: The differences between storage and disposal rationales must be more clear than the use of containment vs. immobilization. The words are synonymous in this context.

Appendix C

Experience indicates that most permits will not have the necessary data for the unsaturated zone TOT calculation. Also, the theoretical approach described in this section leaves too much to the discretion of the applicant.

Page 2-3: The statement in paragraph 3 essentially reverses the sense of the policy for data reliability stated for the saturated zone TOT calculation. Field measurements of moisture content and matrix potential (at least) should be more reliable than laboratory measurements. Without site-specific data the entire exercise may be futile except for calculating worst- or best-case conditions.

Page 3-7, paragraph 1: The average velocity can only yield mean pore water velocity and the mean free path of travel, which may be significantly different from one set of conditions to another.

Page 4-2, paragraph 2: Again, the use of site specific data is vitally important if the unsaturated zone TOT calculation is to have any relevance to actual conditions.

Appendix D

Page 2-5: In interpretation of the ground-water velocity distribution, the uncertainty in calculated velocities from the many cases may put considerably more than 10-15% of the cases within the 100/10 TOT guideline.

Pages 2-11 and 2-12: "g" is the acceleration due to gravity and units should be stipulated for the inputs.

Case study D-1, page 2-36: The same value of effective porosity (i.e. 0.1) was used for all formations. This does not seem reasonable.

Case studies D-4, D-5: No mention has been made of the origin of the data inputs. The source of the data and reliability should be emphasized.

Page 2-88: Equation (1) is incorrect (d_t is missing).
Units for C(x,t) of g/m^2 should be g/m^3.

Page 2-89: Here again, the general term sorption is preferable to either adsorption or absorption.

Page 2-106: The results in Figure 2.4.1 contradict the discussion in the text. The graph shows a positive relationship between TOT and peak concentration, not an inverse relationship as the text claims.

Page 3-8: Descriptive case: The units of hydraulic conductivity should be either cm/sec or $gal/day/ft^2$ to insure data consistency. Transmissivity values can be most misleading when converted to K's.

Pages 4-3 and 4-4 (Table 4.2): The classification scheme for geologic settings ignores hydrologic effects such as recharge, humidity, discharge, pumpage. This would seem to limit its usefulness.

Appendix E

Page 2-22: The preparation of water level contours should include a consideration of vertical gradients and the need to use water levels measured in wells which are screened in the same formation. It would be helpful to emphasize these aspects to the permit writer.

Page 2-24: Some reference should be given for the statement that K values are log-normally distributed.

Page 2-24 (last sentence): Should specify the actual level of confidence (90%, 95%) implied.